A320 Alerting Issues – Loss/degradation of GPS

1. Initiating Condition: Poor GPS satellite availability or geometry leading to decreased GPS signal integrity

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	Accuracy Level "Low" displayed in amber on FMGC PROG page; and on the same page, the displayed EPE value exceeds the RNP value	EPE>RNP		PROG page must be manually selected by pilots to monitor navigation accuracy level		
	"NAV ACCUR DOWNGRAD" displayed on NDs	EPE>RNP				Alert cannot be cleared while condition is active
	Amber "NAV ACCUR DOWNGRAD" displayed on MCDU scratchpad	EPE>RNP				Alert can be cleared on MCDU keypad
	"GPS PRIMARY LOST" amber caution alert on Navigation Displays	GPS input to navigation system rejected when EPE > .28			Inhibited liftoff through 1500 feet and touchdown through end of flight	Alert cannot be cleared while condition is active
	Amber "GPS PRIMARY LOST" on MCDU scratchpad	GPS input to navigation system rejected when EPE > .28			Inhibited liftoff through 1500 feet and touchdown through end of flight	Alert can be cleared on MCDU keypad
	"TERR STBY" displayed on ECAM E/WD (green, or amber T-O thru 1500 feet and 800 feet to touchdown)	"FMS position error exceeds a specific limit "			Inhibited when >8000 feet above local terrain per database	
Aural Alerts	Triple-click alert	GPS primary lost (EPE>.28) while performing non-ILS approach				
Tactile Alerts	None					

A320 Alerting Issues – Loss/degradation of GPS

1. Initiating Condition: Poor GPS satellite availability or geometry leading to decreased GPS signal integrity – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	None					
Aural Cues	None					
Tactile/Somatic Cues	None					

Expected Pilot Response(s)

- Perform ECAM procedure for NAV FMS/GPS POS DISAGREE (if it is presented).
- As directed by ECAM, verify position using alternative means (e.g., radar, DME).
- During GPS/RNAV/RNP approach, execute missed approach (also directed by the NNP but timely response is required so may not be able to wait for checklist).
- Using the NNP, consider turning off the terrain clearance warning system using GPWS TERR pushbutton.

Possible sources of confusion with regard to pilot response(s)

- NAV ACCUR DOWNGRAD and GPS PRIMARY LOST alerts do not cue an ECAM procedure, yet there are procedural steps associated with these alerts.

How does pilot know condition is resolved/recovered?

- EPE<RNP.

Issues with regard to multiple concurrent non-normal conditions

- Loss of terrain clearance warning.
- False terrain clearance warning.
- Loss of separation from air traffic (ADS or NextGen navigation/surveillance).

A320 Alerting Issues – Loss/degradation of GPS

2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	"GPS PRIMARY LOST" on PFDs and Navigation Displays	Only if EPE>.28, in which case GPS input to navigation system is rejected; this may not happen in a spoofing that involves introduction of false GPS position			Inhibited liftoff through 1500 feet and touchdown through end of flight	Alert cannot be cleared while condition is active
	Amber "GPS PRIMARY LOST" on MCDU scratchpad	Only if EPE>.28, in which case GPS input to navigation system is rejected; this may not happen in a spoofing that involves introduction of false GPS position			Inhibited liftoff through 1500 feet and touchdown through end of flight	Alert can be cleared by (xxx)
	Accuracy Level "Low" displayed on FMGC PROG page, and on the same page the displayed EPE value exceeds the RNP value	Does not occur immediately when GPS input is lost, but rather, only if and when EPE degrades to >RNP		PROG page must be manually selected by pilots to monitor navigation accuracy level		
	On lower ECAM display: NAV FMS/GPS POS DISAGREE (amber) and AC POS…CHECK (blue)	FMC position differs from either GPS position by > .5nm			Inhibited 80 knots through liftoff	
	Master caution light	FMC position differs from either GPS position by > .5nm			Inhibited 80 knots through liftoff	
Aural Alerts	Triple-click alert	Only if GPS primary lost (EPE>.28) while performing non-ILS approach				
	Single chime	FMC position differs from either GPS position by > .5nm			Inhibited 80 knots through liftoff	

A320 Alerting Issues – Loss/degradation of GPS

2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Tactile Alerts	None					
Visual Cues	Possible visible map shift, if the system makes a position change or correction while a pilot is looking at the navigation display		Map shift, if it occurs, may not be noticed, or if noticed the caused will be unclear and it will not be evident whether the shift was to a more or less accurate position. In the absence of map shift and FMS text alerts there will be no alerting or cueing to false position.			
Aural Cues	None					
Tactile/ Somatic Cues	None					

Expected Pilot Response(s)

- Perform ECAM procedure for NAV FMS/GPS POS DISAGREE.
- As directed by ECAM, verify position using alternative means (e.g., radar, DME).
- Identify false information.
- Eliminate source of false information from the position solution (de-select GPS).
- During GPS/RNAV/RNP approach, execute missed approach (also directed by the NNP but timely response is required so may not be able to wait for checklist).
- Using the NNP, consider turning off the terrain clearance warning system using GPWS TERR pushbutton.

Possible sources of confusion with regard to pilot response(s)

- Without effortful investigation it may not be clear to the pilot which of the navigation sources is/are providing the false position; also, because of the normally high accuracy of GPS pilots tend to believe its information and downplay the other sources. As a result, the FMS position may drift or shift into a false position that may appear, to the pilots, to be a malfunction of the IRS or Radio position sources.

A320 Alerting Issues – Loss/degradation of GPS

2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS – Cont.

How does pilot know condition is resolved/recovered?

- Verifying position after reverting to alternative navigation.

Issues with regard to multiple concurrent non-normal conditions

- Loss of terrain clearance warning.
- False terrain clearance warning.
- Loss of separation from air traffic (ADS or NextGen navigation/surveillance).